

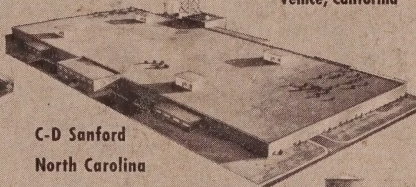
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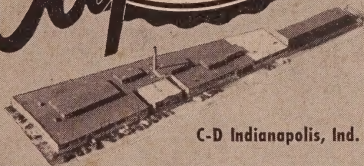
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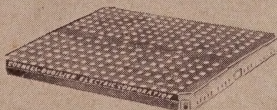
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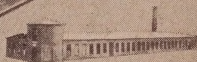
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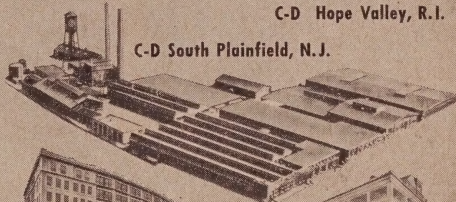
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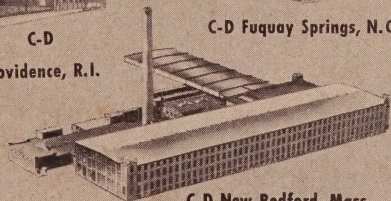
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No. 2

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TRANSFORMER TESTS AND MEASUREMENTS

The practical electronics worker tends to take transformers for granted. It has been only in recent years, with the rise of high-fidelity audio equipment, that the technician has become concerned to any great extent with transformer performance. Countless power transformers have been installed in equipment and promptly forgotten, once it has been established that the output currents and voltages meet specifications. In general, the problem of transformer measurements has arisen only when an unlabelled unit had to be identified.

Extensive laboratory measurements may be performed on transformers of all categories. However, most of these are of interest primarily to the transformer design engineer and not so much so to the practical technician. This article describes practical tests and measurements which enable the technician to check important operating characteristics of transformers and which may be performed with conventional instruments.

Precautions in Testing

Several preliminary remarks are in order regarding precautions to be taken when making transformer measurements. These concern both the accuracy of the tests and the safety of the operator.

Waveform Purity. Harmonic distortion must be at a minimum in any sine-wave signal employed in transformer testing. If the signal has appreciable harmonic content, a suitable filter must be operated at the output of the

generator to purify the waveform to the greatest practicable extent.

Iron-cored transformers, like most such devices, can introduce appreciable distortion when they are operated at certain critical current levels. This distortion gives rise to inaccuracies of measurement when v-t voltmeters are employed. For this reason, it is important that both input and output test voltages be monitored (e.g., with an oscilloscope) for wave shape, and that the test-voltage amplitude be reduced to a level giving good waveform. If it is not permissible to reduce the voltage to this level, suitable corrections of the voltage measurements must be made to compensate for the error due to distortion.

Elimination of Stray Fields. Unshielded transformers are subject to considerable stray-signal interference and accordingly must be protected from extraneous magnetic fields during tests. If this is not done, the accuracy of measurements will be impaired by residual voltages induced by these fields. The most troublesome fields usually are those arising from nearby power wiring or power line-operated equipment.

The transformer under test must be situated in an area free from such fields. If this is not possible, the transformer (and sometimes all of the test equipment, as well) must be operated inside a well-shielded chamber. It is important to note that often a poorly shielded signal generator itself is the source of a disturbing magnetic field.

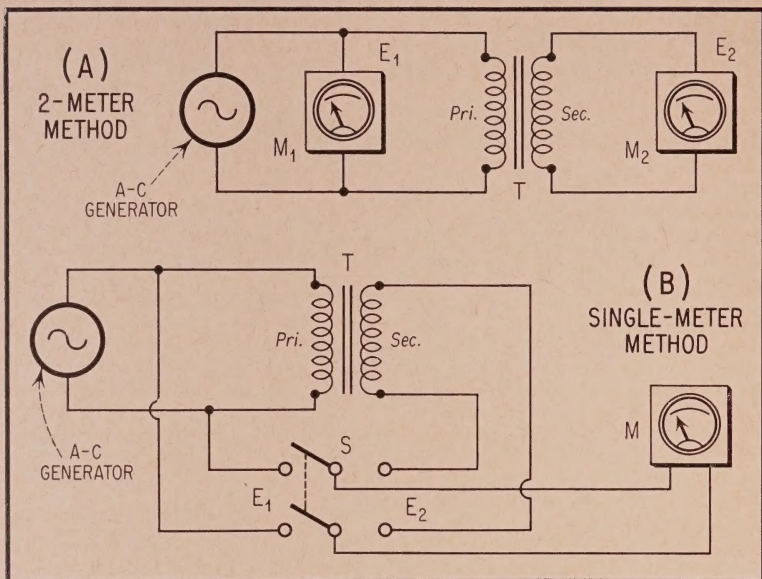


Fig. 1. Turns Ratio.

In the few instances in which a transformer must be tested in an interfering field and satisfactory external shielding cannot be provided, the transformer sometimes may be oriented so as to null, or at least greatly minimize, the induced stray voltage.

Selection of Test-Voltage Amplitude. Depending upon the type of core material used in building a transformer, considerable non-linearity may be encountered in transformer measurements. This necessitates careful choice of test-voltage amplitude. In most cases, it perhaps will be best to test the transformer at the voltage level at which it normally will be operated. But this is not always practicable, especially if high distortion levels occur at this voltage. It is

advisable, however, to keep the voltage well below the amplitude at which core saturation appears, unless the purpose of the test is to check saturation characteristics.

Selection of Test Frequency. Equally important as amplitude is the frequency of the test signal. Since the performance of the transformer will not be the same at widely separated frequencies (except to some extent in wide-range audio transformers intended for high-fidelity applications), the test frequency must be chosen well within the frequency ratings of the transformer. Several obvious rules of thumb apply here: Power transformers should be tested at the line frequencies at which they normally will be operated (e.g., 25, 50, 60, 120, 400 cps); single-frequency tests of audio

transformers usually are made at 400 or 1000 cps, but a response run on an audio transformer would be made at a wide selection of frequencies throughout the a-f spectrum.

Safety Precautions. Since many transformers have step-up turns ratios, they are capable of delivering high voltage across one or more secondary windings when a test voltage is applied to the primary. This introduces two hazards, one to the equipment and the other to the operator.

A proposed test setup should be examined carefully on paper before the circuit is wired and a test voltage applied, in order to determine the possible location and amplitude of any high voltages. If it is evident that test instruments will be damaged by these voltages, the test voltage amplitude must be reduced or heavier instruments employed.

It is important that the operator be well aware of the location of any high-voltage points in the test circuit and that he avoid bodily contact with these points. The electric shock hazard in transformer testing is not to be dismissed lightly. Two factors oper-

ate to the danger of the technician. One is the fact that the voltages are alternating, and the other is that in many instances the test signal is of low frequency (usually 60 cps). Studies have shown that these frequencies are more conducive to electrocution than some higher ones.

Turns Ratio

From the very nature of the transformer, turns ratio is perhaps the basic parameter of this component. Turns ratio ordinarily can be measured by applying a known a-c voltage to the primary winding, measuring the open-circuit voltage induced across the secondary (using a v-t voltmeter to minimize loading),* and taking the turns ratio as the ratio of the secondary voltage to primary voltage.

Figure 1 shows the test setup for turns ratio measurement. The arrangement shown in Figure 1(A) is the easiest to use but requires two a-c vacuum-tube voltmeters, M_1 and M_2 . The generator voltage is adjusted to some convenient value of primary voltage, E_1 , indicated by meter M_1 . Meter M_2 then indicates the open-circuit voltage, E_2 , induced across the second-

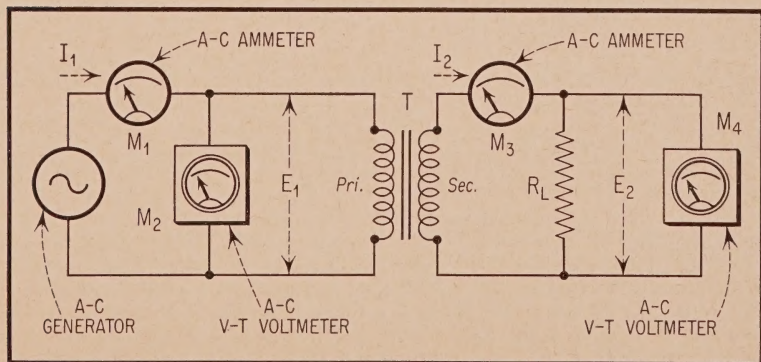


Fig. 2. Efficiency Measurement.

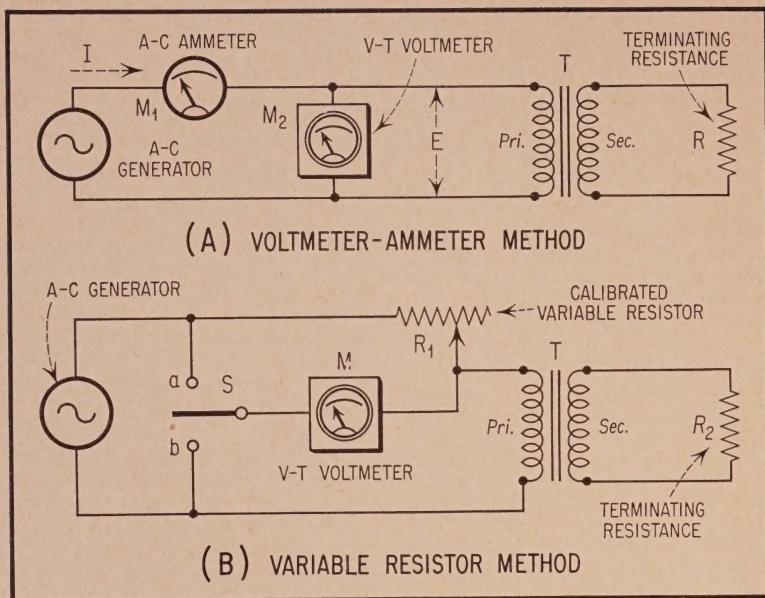


Fig. 3. Winding Impedance Measurement.

ary. The turns ratio then is taken as the quotient E_2/E_1 . When possible, it is convenient to adjust E_1 to 1 volt. Voltage E_2 then automatically indicates the turns ratio, and no calculations are required in the case of a step-up ratio.

Two voltmeters not always are available for this measurement. Figure 1(B) shows a circuit employing a single meter which is transferred between the primary and secondary portions of the circuit by means of a dpdt switch, S. When the switch is thrown to its left setting, primary voltage E_1 is indicated by the meter; and when it is thrown to the right, secondary voltage E_2 is indicated. The single-meter method has the disadvantage

that a change in primary voltage is not evident to the operator if it occurs during switching operation, and this can lead to significant error in the indicated turns ratio.

It is advisable to check turns ratio at a low frequency, since the effect of capacitances in and between the windings become more significant and introduces larger errors at high frequencies.

Impedance Ratio

If the turns ratio first is measured accurately, the corresponding impedance ratio may be determined by means of a simple calculation. Thus, the impedance ratio is the square of the turns ratio: $Z_2/Z_1 = (N_2/N_1)^2$.

This is an important characteristic when dealing with a-f matching transformers.

Efficiency

Figure 2 shows a setup for measuring transformer efficiency. In this arrangement, a-c ammeter M_1 indicates the primary current, I_1 , of the transformer. V-t voltmeter M_2 indicates the primary voltage, E_1 . The resistance of load resistor R_L is chosen such that the current drain from the transformer secondary will equal the rated secondary current output. A-c ammeter M_3 indicates the load current, and v-t voltmeter M_4 the load voltage.

Power input (P_1) to the transformer is equal to $E_1 I_1$, and power output is $E_2 I_2$. In each instance, E is in volts, I in amperes, and P in watts. The efficiency of the transformer is the ratio of output power to input power: P_2/P_1 . Expressed as a percentage, efficiency = $100(P_2/P_1)$. Using the current and voltage readings obtained with the setup shown in Figure 2, efficiency (%) = $100(E_2 I_2/E_1 I_1)$. Efficiency may be checked at different input power levels and output power levels by proper adjustment of the generator output and load resistance.

In the interest of circuit simplification, voltmeter M_4 may be omitted if resistance R_L is known accurately,

and the output power taken as $I_2^2 R_L$. Similarly, ammeter M_3 might be omitted, and the output power taken as E_2^2/R_L . A single voltmeter also might be used by switching it between the primary and secondary in the manner shown in Figure 1(B). In lieu of the primary and secondary ammeters and voltmeters, a primary wattmeter and secondary wattmeter may be employed in the conventional manner. This will reduce the number of calculations required, since these latter meters indicate power values directly.

Voltage and Current Characteristics

The circuit shown in Figure 2 may be used also to check the voltage and current characteristics of a transformer.

In this application, the generator voltage is adjusted to a value E_1 corresponding to the rated primary voltage of the transformer (e.g., 115 v for a common power transformer). Load resistance R_L is adjusted for a current drain, I_2 , equal to the rated output current of the transformer. The resulting secondary voltage, E_2 , is indicated by voltmeter M_4 , and the corresponding primary (line) current is shown by ammeter M_1 .

Impedance of Windings

When the magnitude of the imped-

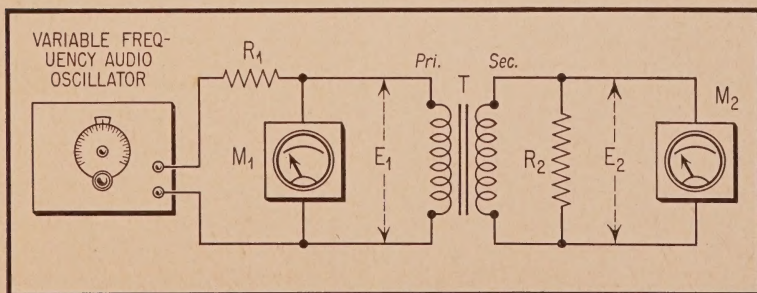


Fig. 4. Frequency Response Test.

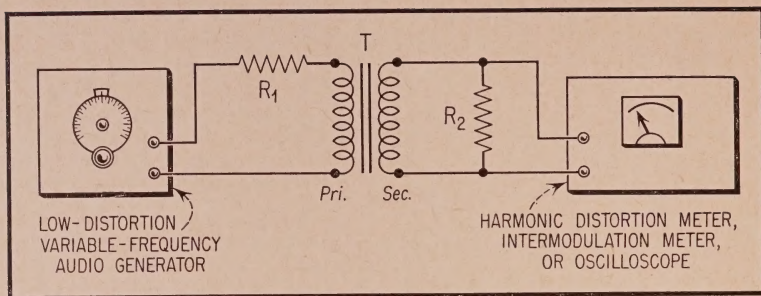


Fig. 5. Distortion Measurement.

ance of a transformer must be known, one of the circuits shown in Figure 3 may be used for its measurement. In each circuit, the primary is shown under measurement but the impedance of the secondary is measured in the same manner simply by interchanging the position of the two windings in the circuit.

In each circuit, the unused winding is shown connected to a terminating resistance. This resistance may be made equal to the impedance into which the winding is designed to operate (e.g., 3.2 ohms in the case of a speaker-driving audio output transformer). However, in some cases, the impedance of a winding must be known under conditions when the unused winding is unterminated, and the resistor would not then be used.

In the circuit shown in Figure 3(A), the impedance (Z) is determined from the current (I) through the winding of interest and the resulting voltage (E) across it: $Z = E/I$, where Z is in ohms, E in volts, and I in amperes. The generator voltage is adjusted to pass the desired current through the winding. The current is kept well below the saturation level of the transformer core, and the voltage is inspected for purity of waveform. Unless it is required to make the

test near the saturation level, the lowest usable signal amplitude should be employed.

The circuit shown in Figure 3(B) uses an accurately-calibrated variable resistor, R_1 , to determine the impedance of the winding. The v-t voltmeter, M , is switched successively across resistor R_1 (when switch S is thrown to its position a) and across the winding (when S is at b). In the first position, the meter reads the voltage drop, due to signal current, across R_1 , and in the second position reads the voltage across the winding. Switch S is thrown alternately back and forth while R_1 is adjusted, until a point is reached at which the resistor voltage drop and the winding voltage are equal and the meter deflection does not change as S is thrown. At this point, the winding impedance (Z) equals the setting of resistor R_1 and may be read directly from the R_1 calibration (i.e., $Z = R_1$ in ohms).

Frequency Response

Frequency response is an important characteristic of transformers intended for use in wide-band, high-fidelity audio equipment. A test of frequency response essentially is a comparison of output voltage with a constant input voltage at a number of selected fre-

quencies over a wide range. In a high-quality transformer, the output voltage is constant within ± 1 db from 10 cps to 50 kc or higher.

Figure 4 shows the circuit employed for measurement of frequency response. Here, resistance R_1 is equal to the rated primary impedance of transformer T, and resistance R_2 equals the rated secondary impedance. Separate v-t voltmeters, M_1 and M_2 , are provided for reading input (primary) and output (secondary) voltages, E_1 and E_2 respectively. However, a single voltmeter might be switched between primary and secondary in the manner shown in Figure 1(B).

At each test frequency, voltage E_1 is set to the prescribed value, as shown by meter M_1 , by adjustment of the output control of the audio oscillator. The corresponding output voltage then is read from meter M_2 . Ideally, E_2 would have the same value at all frequencies, yielding a flat response curve. This is not true in practice, however, the curve rising or falling as the result of transformer parameters. The rise or fall of response may be measured with respect to the response at some selected frequency, say 1000 cps, or with respect to a long flat portion of the curve.

Distortion

Iron-core transformers, unless of high quality, can introduce appreciable distortion, especially when they are operated at relatively high current levels. The audio technician will be interested particularly in harmonic distortion and intermodulation distortion.

Figure 5 shows a circuit for distortion measurement. The test signal is supplied by a low-distortion, variable-frequency audio oscillator or signal generator. When intermodulation measurements are to be made, this generator is a double-frequency instrument, supplying an amplitude-modulated signal proportioned according to either SMPTE or CCIF specifications. The transformer primary winding is connected in series with impedance-matching resistor R_1 , and the secondary in parallel with impedance-matching resistor R_2 , as described in the preceding section on Frequency Response.

The test signal is adjusted to various desired amplitude and frequency values, throughout the voltage range and frequency range of interest, by means of the generator controls. The amplitude of this voltage should be measured with a vpt voltmeter con-

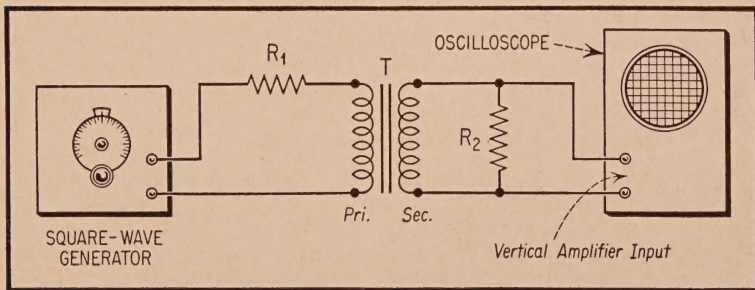


Fig. 6. Square-Wave Response.

nected in parallel with the transformer primary.

The selection of the output measuring instrument depends upon the type of distortion to be checked. It may be either a harmonic distortion meter, wave analyzer, or intermodulation meter. The operation of each of these instruments has been described in earlier issues of the C-D CAPACITOR (See References). If neither instrument is available, an oscilloscope may be used and the distortion level determined from observations of the wave pattern.

Whenever possible, it is advisable to test audio output transformers at their rated power levels. Very often, however, this introduces the problem of obtaining a low-distortion power signal. It is advantageous also when checking the intermodulation distortion of an output transformer to employ the actual loudspeaker as the terminating load, rather than a pure resistance, R_2 .

Square-Wave Response

Checking a transformer with square waves permits a rapid appraisal of the unit with respect to phase and frequency characteristics. A transformer which reproduces faithfully a square wave may be assumed to have good frequency response and low phase shift throughout the band extending 1 decade on each side of the fundamental test frequency.

Figure 6 shows the circuit for square-wave testing of a transformer. Here, the transformer primary is connected to a series, impedance-matching resistor (R_1), and the secondary to a parallel, impedance-matching resistor (R_2) in the same manner explained for the frequency response test (Figure 4). The square-wave generator may or may not be tunable, depending upon how many test frequencies are required by the operator. The oscilloscope controls are set for one or two com-

plete square-wave cycles, with internal sweep and internal synchronization operating.

To obtain a good appraisal of a transformer, the square-wave test usually need be performed only at two or three frequencies in the audio spectrum: e.g., 50, 1000, and 10,000 cps. Interpretation of square-wave patterns has been explained in earlier issues of the C-D CAPACITOR (See particularly Reference 9).

REFERENCES

The following C-D CAPACITOR articles will be found helpful in applying the principles outlined in the present article.

1. Distortion, Its Meaning and Measurement, January 1949.
2. Dual-Range Impedance Meter, August 1950.
3. Intermodulation Measurements in Audio Amplifiers, August 1951.
4. Improved Bridge-Type Distortion Meter, September 1951.
5. Intermodulation, Up to Date, October 1952.
6. Technique of Wave Analysis, March 1953.
7. Frequency and Phase Measurements with the Oscilloscope, June 1954.
8. Power Measurements in Electronic Circuits, August 1954.
9. Square Waves in TV Testing, November 1954.



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NEED — Radio test equip. unused tubes and parts. Have complete outfit for photo-journalist including 2 new reflex cameras and an enlarger, Luther Hoffman, 678 Princeton St., Palmerton, Pa.

WANTED — Manual or schematic of McMurdo-Silver Corp. "Masterpiece", 19 tube, 5 band radio, Mfg. No. 1731, serial No. 696052. Albert Salto, 308 Vine St., Sparta, Ill.

FOR SALE — Portable Precision 920 tube checker analyzer. Cost \$180. Excellent cond., \$45 gets it FOB. James Saunders, 70-23 45th Ave., Woodside 77, N. Y.

TRADE OR BUY — Will trade Triplett 2413 tube tester, for tester with DC voltages, other test equip., cash if bargain. R. B. Johnson, 3922 W. 108 St., Inglewood, Calif.

SELL OR TRADE — Unused B and W 75 ohm low-pass xmitting filter, \$10; 100 w. rack and panel xmitter PP 807's 80-10m VFO xtal, \$100; 250 w. final PP T55's with speech amp, modulator and xtal mike, \$75. P. Brothroyd, Box 142-G, Sparta, N. J.

SELL — HT-4B (BC-610) Hallicrafters xmitter with speech amplifier and antenna tuning unit, \$295. Tom Howard, Box 19, Boston 1, Mass.

WANTED — Instrument rectifiers for volt-ampere meters, also old instruments with salvageable parts. William M. Kelley, R 2, Box 522, Hickory, N. C.

WANTED — Tape recorder and good communications rcvr. Must be A-1 cond. and reasonable. Johnny Wood, Box 723, Tyler, Tex.

FOR SALE — Dumont 175A laboratory scope, re-modified amplifier, antennunnuators, hi-sensitivity, good cond. Best offer, local please. J. Falotico, 1946 51st St., Brooklyn 4, N. Y.

FOR SALE — Philco sig. gen. 120 Kc. to 35 Mc. AC operated, modulation, \$10; Carter genemotor 5.5 v. DC input, 600 v. DC output at .175A. Both \$18 plus postage. Need AC ammeter. Robert Cobaugh 29-29 213 St., Bayside 60, N. Y.

SELL OR SWAP — Assortment of radio components, xformers, chokes, condensers, coils, etc. Want mobile gear and-or photographic equipment. I. E. Aston, R. D. 3, Box 134, Lancaster, Pa.

FOR SALE — Hallicrafters S22R HF, BCST and Aircraft marine rcvr, perfect cond., \$30. William Romain, 28 Avon Place, Staten Island 1, N. Y.

TRADE — All parts of Emerson Radio (3 speed) Phono comb. on mounting panels for AC-DC operation, with extra matching changer. Want SW rcvr and tube tester. D. Pappas, 1615 East 54th St., Brooklyn 34, N. Y.

SELL OR TRADE — BC-223 xmitter with 2 coils, PE 103 gen., 16" Mot. TV console, 4 carbon mikes, complete, \$75. L. W. Bostedor, 14346 University Ave., Dolton, Ill.

WANTED POSITION — Experienced Radio — Television Technician, wishes employment in good reliable company, Iowa or Minnesota area. Have own equipment, 10 years experience, completing additional training in June 1957. Can furnish references. Glen Coffin, 3248 W. Potomac, Chicago 51, Ill.

FOR SALE — 5" Eico scope, \$45; tube tester with multi meter with roll chart, \$25; NRI battery operated sig. gen. with multimeter to 20 Mc. Frank S. Townsend, 81 Court St., Bath, Maine.

WANTED — Miscellaneous QST's before 1954, CQ's and Popular Electronics before 1956 in good cond., good all-band or 10-15 quad. Dan Barr, 7582 East Green Lake Way, Seattle 3, Wash.

FOR SALE — Good GI recorder phono assembly, 33 $\frac{1}{3}$ and 78 rpm, \$16; Shure magnetic recording head type 96-36A, \$3; Regency RC-600 UHF converter 1. n., \$18 all plus postage. Austin Wardman, 106 Rossmore St., East Pittsburgh, Pa.

WANTED — Good UHF converter, reasonably priced. Uscinowski, RD2, Cambridge, N. Y.

WANTED — Old issues of C-D Capacitor also Radio News 1940-1946 inclusive and 1922 and prior — will buy or trade. Bob Farmer, Plainville, Tex.

FOR SALE — Harmon Kardon Hi-Fi FM AM tuner A200, 1. n., \$50. Ed Slusask, 3520 W. 49 St., Cleveland 2, Ohio.

FOR SALE — Eico emission tube tester, excellent cond., used very little, \$25. John F. De Santis, RD 5, E River Rd. So, Fulton, N. Y.

FOR SALE — HRO 5T1 with A-B-C-D plus 15 meter coil with P.S., 1. n., \$145. L. Valentine, Westwood, Mass.

FOR SALE — Viking II, factory wired, push-to-talk, Johnson VFO, LP filter, matchbox, SWR bridge with 5" meter. All reasonable offers considered. Like new. Freedmen, 3 Channel Dr., Kings Point, L. I., N. Y.

SELL-TRADE — Car radios: '42 Plymouth, and Pontiac, '48 Oldsmobile and Buick, many others; C-D 110RT25 power-con, 40 w. modulator, 750 v., 250 Ma supply. Need ham, photo, testing equip. Stan., 2748 Meade St., Detroit 12, Mich.

SELL OR SWAP — Heathkit GD-1B with low frequency coils; Sprague KT-1; Precision combination VTVM sig. tracer with probe; Knight VTYM with HV and RF probes. All in A1 shape. Need mobile converter and Regency TR-1. Don's Radio Shop, Box 367, Silverton, Tex.

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SELL OR TRADE — Complete Amateur station: Viking Adventurer with 40 and 80 meter crystals and key, Hallicrafter's SX-71 rcvr, less speaker, earphones, and log book. All for \$200 or trade for Hi-Fi equipment. Glen Reitenour, Box 787, Opelousas, La.

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FOR SALE — RCP "Do All" sig. gen. model 750, 1. n., with instructions, \$45 P.P. Andy's TV and Radio Service, 13 North Street, Schenectady 5, N. Y.

WANTED — Back copies Review of Scientific Instruments and Audio Engineering. Must be complete yearly runs, good cond. and reasonably priced. M. Brownstein, 4653 Boudinot St., Philadelphia 20, Pa.

WANTED — Recent Radio and TV Servicing Course, either NRI or RCA. State cond. and price. Companion kits desirable but not necessary. Albert Kammel, 128 Weisser Ave., Louisville 6, Ky.

FOR SALE — Morrow 3BR mobile converter 75-20-10 meters, perfect cond., \$30; 1950 Chev. car radio, built in noise limiter and power plug for converter, \$20. William Hoos, 4317 Barrington Rd., Baltimore 29, Md.

FOR SALE — Philco 933 auto radio speaker separate, \$10; Sarks Tarzian UHF receptor Ch 14 to 46 complete, \$5. All COD. V. Kozma, 12450 NW. 5th Ave., Miami 50, Fla.

FOR SALE — AC operated instructograph in good working cond., 10 tapes, instruction book and key, \$35. Will ship. Stanley Gonet, 211 Sylvan Knoll Rd., Stamford, Conn.

SELL — Hallicrafters S38A rcvr, \$20. Local only. Stuart F. Kelly, 9604 8th Ave., Baltimore 34, Md.

FOR SALE — Hallicrafters SX-88 rcvr, perfect shape, asking \$425 but make offer. R. S. Sturman, 1241 Va. Ave. N.E. P-4, Atlanta 6, Ga.

FOR SALE — Triplett 3441 5" scope, perfect cond., price new \$244, sell for \$100. Ritts Radio Service, 644 N 7th Ave., Tucson 10, Ariz.

TRADE — RCA TV camera for easy closed circuit TV pictures. Swap for what have you? Leo Meister, 321 River Rd., Nutley 10, N. J.

FOR SALE — Complete 1 through 15 Rider Manuals. 1 through 5 unabridged. Binders in excellent cond., \$35 FOB. Harold B. Taylor, 5015 W. Frances, Austin 3, Tex.

SELL OR TRADE — Type 20 DP4 20" pic. tube, and Mallory Inductuner 235944 with built in FM salvaged from Transvision TV rcvr for radio and TV tubes and pilot lamps or cash. Henry Platek, 1128 Marshall Ave., Pittsburgh 12, Pa.

SELL OR TRADE — Ham parts, tubes, transformers, stamp collections, DB-20 Meissner ex signal shifter, etc. Need 51SB exciter, Jones micro-match. Bill Grebe, 518 West Ninth, Loveland, Colo.

SELL OR SWAP — Microphones: Electro-Voice 915, with 8" desk stand, both chrome; also T-17. Want 12" extended range speaker and good P-P 6V6 output xfomer. C. Gabler, 1307 Merriam Ave., New York 52, N. Y.

WANTED — RCA marker generator. Prefer obsolete model WR39A "Television Calibrator." State price and cond. E. F. Pedersen, 1032 North Niagara St., Burbank, Calif.

TRADE — HO equip. for ham gear. Have Pacific engine, 12 freight cars, track, etc. Rudolph P. Fannon, 134 Highland St., Marlboro, Mass.

FOR SALE — 12" TV picture tube GE MW31-3 fits GE HM226-7A, sell or trade for test equipment. John C. Strazza, Jr., 48 Pulaski St., Bloomfield, N. J.

WANTED — Two RCA 45 RPM record changers. Write model, cond., price. E. J. Rodgers, 9708 Elrod Rd., Kensington, Md.

FOR SALE — Dumont 164-E scope excellent cond., \$40; Panadaptor PC-200, \$65, just returned from factory; unused Magnacord PT-6-M mechanism, \$150. Charles H. Elmitt, 4392 Hamilton Ave., Cincinnati 23, Ohio.

SELL OR TRADE — LP changer, \$15; 4 x 40 binoculars, \$2; Radar unit BC-412, \$20; 35mm F2 camera; portable radio; Electronics Engineering, Electric Wiring, \$1 each; Modern Radio, 50 cents. J. Rofchak, Daley Rd., Lapeer, Mich.

SELL OR TRADE — Measurements Corp. 78B sig. gen. 15-25 Mc, 190-230 Mc; 2 Heath scope xformers; HF tubes, klystrons, photo multipliers, large power panel meters, Gibson Grl. Local preferred. E. Gaynor, 154 Cherry Tree Lane, Merchantville, N. J.

SELL OR TRADE — Surplus for yours: TV ant., rotators, boosters, converters, tubes, equip., UHF tuners, etc. Some sealed cartons. Located N.W. Illinois and here, list 25 cents or ex. Top TV Service, Harlingen, Tex.

WANT — 150-172 Mc FM rcvr. Have '49 Olds radio, audio scope, 88-108 Mc FM rcvr to sell or trade. W. E. Fuller, R. 1, 3137 N. Michigan Rd., Dimondale, Mich.

TRADE — Back issues of "The Capacitor," Aerovox "Research Worker," many others. Want APR gear. F. G. Schmidt, 405 N.W. 30 Terr., Ft. Lauderdale, Fla.

WANTED — National "mighty midget" SW-54 radio rcvr in good working cond. State lowest price acceptable. D. Landesberg, 179 Marcy Ave., Brooklyn 11, N. Y.

SELL OR TRADE — Gonset deluxe triband and 3-30, converters 6 or 12 v. good cond. for cash or trade for shotgun; 22; or a converter covering 150-160, 30-40, or 40-50 Mc. E. K. Harkness, 777 Bryant Ave., Winnetka, Ill.

WANTED — CQ magazines for 1945, C-D Capacitor vol. 1, 2, 3, 4, any or all, 1916; Radio 1912 to 1936 QST urgently needed to complete file; also old-time battery set using honeycomb coils. Robert E. Jones, 713 Front St., Catasauqua, Pa.

SELL OR TRADE — Elec. converter 52 VDC to 110 VAC, Heath BE2, Freed Eisemann NR9 speaker, Wireless 12 lighter, Seneca F7.7 lense. Need scope, TV-S.G., res. cap. checker, 10-12" table TV in working order. Snider Radio Service, Leoti, Kan.

FOR SALE — Radio Physics Course — Ghirardi, \$3; TV Fundamentals — Fowler and Lippert, \$5; Basic Radio Course — Frye, \$1.50; Radio, TV, and Radar, \$2; TV Servicing Course — Beitman, \$1.50. C.O.D. V. Zelinskas, 10701 Woodview Blvd., Cleveland 30, Ohio.

SELL OR TRADE — Sentinel portable TV model 100. Plays but needs some repairing. Can furnish diagram. Trade for scope: H. A. Carter, 2548 Princeton Ave., Memphis 12, Tenn.

SELL CHEAP — Signal gen. 90 kc. to 25 mc. less battery, \$5; Stancor 0-8 v. 15 amps. battery eliminator or charger, \$10; genemotor 250 v. at 50 mils., \$5. Send postage. Reeves, 623 Chestnut, Niagara Falls, N. Y.

WANTED — Dumont telle-set model RA-105 (1949), must be in good cond., for cash. Holt Shortell 8911-238 St., Belle-rose 26, L. I., N. Y. Or 11212 Renter St., El Monte, Calif.

FOR SALE — Hallicrafter SX28, good cond., \$115; Eldico TR75 TV, band switching 80 40 20, with VFO and modulator, \$75. Larry Gittings, 117-26 239th St., Elmont, N. Y.

WANTED — Feb. and June 1937 issues of Popular Science magazine. Wayne Sines, R. 1, Box 425, Oakland, Ind.

FOR SALE — Heathkit AR-3 shortwave rcvr, Eico 360 TV-FM sweep gen. and 425 scope. All in A-1 cond. Barry Lynn, 1711 Morris Ave., Bronx 57, N. Y.

SELL OR SWAP — Complete amateur radio station with Hammarlund HQ-120 and unused AT-1, accessories, and many extra parts for tape recorder. Kevin Kokot, 218-14 67 Ave., Bayside 64, L. I., N. Y.

WILL BUY — Condenser checker; record player; describe fully. State price and cond. John E. Doyle, R.F.D. Box, Woodlawn Rd., Richwood Ave., Randolph, Mass.

SWAP OR SELL — Unused commercial mobile xmitter, 10 or 20 meters, 50 w.; RCA 151 portable scope; Gonset 2 meter converter, low pass and high pass filters. Want tape recorder, printing press, power tools or? D. Siegel, 130-18 223 St., Laurelton 13, N. Y.

WANTED — Circuit diagram of Ferret mod. 61 AF generator. E. Nelson, 4108 E. Newton, Seattle 2, Wash.

FOR SALE — Unused '56 Buick selectronic 981708 car radio; Motorola 508, slightly used, complete. M. T. Burkott, 9991 Albion Rd., North Royalton 33, Ohio.

FOR SALE — Eico 425 scope, \$35, 315 sig. gen., \$25. Both in good cond. H. Bell, 3917 Ely Ave., Bronx 66, N. Y.

TRADE — Radio receiving tubes for scope, Hallicrafter S-38, AM-FM set, isolation xformer. G. H. Swiska, 109 E. School St., Woonsocket, R. I.

SELL OR TRADE — Heathkit VFO; AT-I xmitter; Hallicrafters S-38D rcvr; 17BP4 CRT. All in excellent cond. Local only. Al Perlberg, 4621 N. Hutchinson St., Philadelphia 40, Pa.

WANTED — Hickok 533 portable tube tester, also all other Hickok test equip. and parts. Paul Capito, 637 W. 21 St., Erie, Pa.

SELL — W.E. model H.S. 33, telephonics TH37 headphones complete, Astatic 200 S hand mike with switch, each \$4. Peter Carriero, 2260 Haviland Ave., Bronx 62, N. Y.

SELL OR SWAP — Unused Flexarett 2 1/4 x 2 1/4 twin reflex camera with case for \$52 (approx. half price) or good commercial ham xmitter. Don Jeppesen, 2318 Second Ave., Council Bluffs, Iowa.

FOR SALE — Like new 1957 VM tape recorder complete with mike, tape, etc. Jack Fives, 2916 Rockrose Ave., Baltimore 15, Md.

WANTED — Schematic of a plug-in tremolo unit with power supply and foot switch which can be used with any amplifier. S. E. Rajkowski, 11 1/2 Jones St., Etna, Pittsburgh 23, Pa.

FOR SALE — Heath AT-1 xmitter, \$21, and VF-1, \$16, or both for \$35; PP 616's 40 w. modulator, \$20. Lee Owen, R. 1, Ravenna, Ohio.

SWAP — Tubes, phono turntables, capacitors, TV lead, tuners, chassis; cap. analyzer "solar." Need communication rcvr., surplus items. Thomas Rohland, R. 3, Martinsville, Ind.

FOR SALE — Harvey-Wells TBS-50D, \$75; APS-50 AC power supply, \$20; RME MB-3 monitor, \$18; Millen 90671 SWR bridge, \$8; Eldico A-300 antenna tuner, \$15; Instructograph code teacher, \$10. Robert Gossett, 15 Pine Ridge Rd., Weymouth 89, Mass.

SELL OR TRADE — Radio and TV books and manuals, send for list. S. Kardek, 1 Arch St., North Brookfield, Mass.

WANTED — DX100 or Viking II xmitter. Quote price and cond. first letter. Will sell NC100A rcvr and speaker like new cond. Ray Glemser, 6115 N. Lawrence St., Philadelphia 20, Pa.

SELL OR TRADE — 10"-12"-14" TV sets, 16mm sound projection machine. Want Hi-Fi test equip., 10 HP or better outboard motor. Thomas F. Elwood, 22 Butler Pl., Rosebank 5, Staten Island, N. Y.

SELL OR TRADE — Zenith transoceanic 7G605 like new, \$35 or trade for 1954 custom Ford auto radio. Ernest Michailoff, 32 Plymouth Ave., Johnstown, Pa.

SELL OR SWAP — Eico 322 Sig. gen.; good 21FP4 picture tube; high-volt. 30,000 probe for Heath VTVM. Need bar gen. Mock's Radio and TV Service, 923 So. Bridge St., Portland, Ind.

FOR SALE — Lettine 240 xmitter, \$50; Thor 1/2" industrial drill, \$35; Wilcox 2-light strobeflash, charger, \$50; RCA WV97A voltohmmyst, needs minor repair, \$25. Want clean 2 x 3 R. B. Graflex outfit. J. Flanagan, 1249 Cambridge St., Cambridge, Mass.

TRADE — For good camera: electro-voice 606-20 differential dynamic mike 1. n. and Stromberg-Carlson AM-FM chassis 10 w. and speaker. E. De Cobert, 609 Henrietta St., Gillespie, Ill.

FOR SALE — C-H motor control rheostat 30 ohm 115 v. 1320 w. 11.5A, \$7.50; tubes: 354C, 196, \$10 each; Amertran fil. xformer pri. 220 v. 50-60 cy 1Ph, sec. 7.54 v. 24A cased, 2,500 v. insul., \$5. Want — stepper relay. J. M. Hirschinger, 417 Hampshire St., Quincy, Ill.

SELL OR TRADE — Collector's item books: "Radio Engineering Principles," 1919; "Theory of Thermionic Vacuum Tube Circuits," 1927. Gene Brizendine, 1001 Merritt St., Old Hickory, Tenn.

SELL OR TRADE — Photo Fact — TV course, \$1.75; FM Simplified, \$3.50; Cooke Mathematics, \$3.75; Dyke — Carburetors, \$1.50. John Holiday, R. 2, Box 100, Indiana, Pa.

FOR SALE — BC 459A xmitter converted to 12 v., good cond., Micamold XTR1 35 w. xmitter. Make offer. Need new MA meter. C. J. Burket, 711 E. Orange St., Lancaster, Pa.

FOR SALE — DX-35, \$60, excellent cond.

Will consider good rcvr also will swap 2 meter xceiver for used bug. R. Pohorance, 36 Orchard St., Yonkers, N. Y.

FOR SALE — 1954 Sprayberry Radio-TV course. Like new with or without kits. Best offer. Edward Svoboda, Wilber, Neb.

SELL OR TRADE — Edwards Fidelotuner 5 tubes sel. rect.; Simpson 351 TV ant. compass field strength meter; 200 pre war tubes all like new. Need good UHF converter; TV sweep gen. V. D. Walker, 716 North St., Pittsfield, Mass.

TRADE — Typewriter for short wave radio. Bob Robinson, 612 Charlotte St., Utica, N. Y.

FOR SALE — Split stator cond. .078" spacing, \$4; dynamotor PE-101-C, \$5; win. mod. 70 cal. 270, super grade, cond. excellent, \$140. Glenn W. Riddles, 66 W. Glendale St., Bedford, Ohio.

SWAP — Full set of golf clubs and bag, Zeiss Ikon 3 1/4 x 4 1/4 press camera, Prem 6 4 x 5 press camera, both good cond., for used tape recorder or? Emory Corron, 4096 Redonda Lane, Dayton 6, Ohio.

SELL OR SWAP — Arel 12" photog. slide rule; assorted tubes. Want test instruments, any shape. Charles Butler, 4547 Talisman St., Torrance, Calif.

SWAP — 2 Portor phones Stewart-Warner on citizen band 465 Mc with battery and 1 AC powerpack for set, for 16mm camera and projector for sound. Film in good cond. Hobert Kiser, Box 389, Clendenin, W. Va.

FOR SALE — Master Craft mini-sig. vest pocket transistor AM test oscillator, \$4.25 and Emico AC voltage tester, \$2.25. Money orders. E. L. Giroux, 735 Park Ave., Hoboken, N. J.

WANTED — Tubes: xmitting receiving, TV, special purpose, diodes, transistors, klystrons, magnetrons, ignitrons, ruggedized, G-M counter tubes, multipliers, subminiatures, etc. Will pay cash or swap for choice tubes and equipment. C. D. Gensler, 56 Crosby Street, New York 12, N. Y.

SELL OR TRADE — BLA6 Pioneer light plant. 500 w. 120 v. AC and 200 w. 8 v. DC, \$125 or trade for 1500-2000 w. belt-driven 120 v. AC generator only. Tom Tilton, 65 Rheem Blvd., Orinda, Calif.

WANTED — BC 614 speech amp., also antique rcvrs and equip. vintage 1920 and older. R. Husted, 105 N. Chester Pike, Glenolden, Pa.

FOR SALE — Two PE-103 dynamotors, like new, \$17.50 each; 3" Triplett 200 milliamper meters and .5 ampere thermocammeters, external thermocouples. Also Thordarson rcvr xformers, 200 milliampere, 800 v. center tapped, 6 v. fil. Donald Slattey, Rt. 2, Loveland, Colo.

WANTED — BC-221's. Highest cash price paid for those unaltered models with modulation and with original calibration books. Even those without modulation accepted. Wire or write: Bolton Laboratories, Inc., Bolton, Mass.

TRADE — Large assortment radio parts for US and UN Mint or used stamps. Andrew E. Lontka, 130 Beech St., Kearny, N. J.

SELL OR SWAP — Gibson Girl handcrank gen., APN-1 altimeter, electromechanically-driven sweep condenser, EMCAM sig. gen. Want stamp collection, transistors and associated parts, or cash. L. Miller, 417 Wagner Ave., Washington, Ill.

TRADE — Like new 21" Philco TV table model for complete set of Encyclopedia Britannica, 1956 copyright. Walter Huey, Jr., 118 East Franklin St., Monroe, N. C.

SELL OR TRADE — Fairchild L99 disc recorder with 541-A cutter; 3 KVA pole xformer 220 7200 v.; complete Bendix 25 w.; 152-162 Mc base station including antenna and co-ax. Want audio and broadcast equip. Roland Jordan, Jr., WRWJ, Selma, Ala.

TRADE — 16mm silent projector and films for testing and xmitting equip. Have radio parts for sale. Joe Ashley, 410 Riverbend Dr., West Monroe, La.

FOR SALE — Simpson-capacitance and in-circuit leakage tester; Precision ES-500A scope and probe set SP-5; E-400 sweep gen.; EMC-208 tube tester. All with leads and manuals, \$250. Wilk's TV Service, 684 Hudson Blvd, Bayonne, N. J.

FOR SALE — Jackson 106 RF sig. gen., 100 kcs-54 mcs fundamental, 216 mcs harmonics, 400 cycles audio. Complete with output cable and instruction manual. No scratches, perfect operating cond., \$38 FOB. Andrew Smith, 24 Lee Ct., New Rochelle, N. Y.

WANTED — Heathkit VFO, Q multiplier, tube caddy, leather case for Simpson 260 multimeter, vibroplex bug, CR 1A or FT243 xtals. Harold Smith, Bldg 41, NAS, Cecil Field, Fla.

FOR SALE — Recent Advanced Radio Communication Engineering correspondence course, college level, excellent cond., \$100, prepaid in U.S. Lewis M. Owens, Box 384, Columbia, Ky.

SWAP OR SELL — Webster-Chicago 80 wire recorder; Lear xmitter 75W; Supreme 661 sig. gen.; Harvey-Well's aircraft transceiver. Fred Welch, 845 Allingham, Van Wert, Ohio.

FOR SALE — Crystal controlled amateur xmitter from Handbook design: oscillator, 2 multipliers, and 75 w. output stage. Parts alone worth \$60. Best offer. Lt. Robert M. Rubin, 136 Ringdahl Court, Rome, N. Y.

SELL OR SWAP — Hi-Fi system including AM-FM tuner integral drive motors for remote operation, push-pull parallel output 6V6's, 20 w. amplifier, 14" speaker. Perfect operating cond. Want Polaroid camera or test equip., local preferred. M. Bierman, 118-14 83 Ave., Kew Gardens 15, N. Y.

WANTED — FM tuner or set, secondary crystal standard or generator and FM sig. gen. Have bathtub condensers, Precision sig. gen. and other gear. O. Zethmeier, 1123 Woodycrest Ave., N. Y. 52, N. Y.

WANTED — Copy of the Sylvania "How to Service Radios with an Oscilloscope." Louis Tonik, 1505 N. 6th St., Philadelphia 22, Pa.

WANTED — Equipment type octal sockets. Will swap parts or pay cash. Dan Rosa, 590 Eagle Ave., Bronx 55, N. Y.

SELL OR SWAP — Heathkit VTVM model V-7, perfect cond. and Heathkit SG-8 RF generator. Want spinning gear rod, reel, etc. W. Nicholas, 150 Rose St., San Francisco 2, Calif.

FOR SALE — General Industries unused DSS 3-speed turntable and BJ arm with plug-in head for standard cartridges, \$25. Norman W. Tetenman, 2350 E. 27 St., Brooklyn 29, N. Y.

SELL OR TRADE — Misc. crystals in FT-243 holders for 80, 40, 6, and 2 meters, 6 for \$1. Send for list of frequencies. Ronald E. White, 403 Alden Rd., Hayward, Calif.

FOR SALE — 30 used coin radios, good cond., 15 on metal stands. Any reasonable offer accepted. John Dittmer, Box 505, Harrisburg, Pa.

WANTED — ICS courses in electrical and mechanical engineering, the calculus, and patents. R. F. Moore, 26 Auburn Rd., West Hartford 7, Conn.

FOR SALE — Regency transistor radio; Teletest capacitester; 2 Supreme VOM's. Frank D. Witmer, 39 Oneida Rd., Camp Hill, Pa.

FOR SALE — Kolster K-20 radio in good shape. Make offer. You pay shipping charges. Droesch Radio-TV Service, Box 147, Burkettsville, Ohio.

SWAP OR SELL — Wardflex reflex camera, f3.5 complete flash, filters, tripod, meter for S-53A rcvr, complete set law books, or \$50. What have you in radio and TV course? Arsenault, Box 313, No. Oxford, Mass.

WANTED — Plate xformer that will deliver 4000 volts at one amp after filtered and high voltage gear. Cordell Damron, R. 3, Pikeville, Ky.

TRADE — Spencer 10X turret lab microscope, adjustable, illuminated, magnifier stage 2 eye pieces, 3 objectives 1.8 oil, portable leather case for top Ham rcvr, Hi-Fi or TV'd xmitter. G. E. Howarth, 216 1st Ave., E. Oskaloosa, Iowa.

FOR SALE — VM-700 tape recorder, Viking 1, National 173 rcvr, tri-band conv., Presto Junior recorder J-5. Want AC power supply for Elmac 67, Johnson match box. Matthew Beha, O'Neill, Neb.

SELL OR SWAP — Webcor 210-1C tape recorder, exc. cond. Want Hi-Fi like Heath A-9B, Garard RC-80, Diamond cart., Electrovoice SP12B, Arex RJ Baffle. Dubov, 3100 Brighton 2nd St., Brooklyn 35, N. Y.

SWAP OR SELL — Like new Gonset 2 meter communicator and 14" and 17" portable TV; xmitting tubes, meters. Want BC-224, 348, 788C, R5 ARN-7, ARC-3. D. E. Cimino, 2246 Betty Lane, Beverly Hills, Calif.

FOR SALE — Sylvania 7" TV scope type 400 in like new cond., \$125; FM rcvr 11 tube 6 v. DC crystal controlled 152 Mc. crystals self-contained vibrator supply, \$40. Conrad Radio, 12908 Lorain, Cleveland 11, Ohio.

WANTED — FM tuners — advise make, cond., model, and lowest price; also AM-FM radios. Mercury Radio, 433 S. Wabash Ave., Chicago 5, Ill.

FOR SALE — VM 950 record changer with base and GE triple play cartridge, \$15. Sold as is but will demonstrate. T. Popel, 1223 Elm Ave., Brooklyn 30, N. Y.

SELL OR TRADE — Little used four volume loose leaf RCA tube handbook HB-3. Binders fair to good, sheets to date, renewal paid to Sept. 57. More info on request. W. S. Kemper, 825 NW 149 Tr., Miami 50, Fla.

WANTED — High voltage xformer at least 50 to 65 KV or several 10 to 20 KV neon xformers. Will pay cash or trade electronic equip. Reptile Research Laboratory, 429 N. Goodsell St., Evansville 8, Ind.

FOR SALE — Antique radio rcvrs, all makes, 1920 thru 1927; old tubes, recordings, magazines, catalogues, and radio phono combos. Howard C. Bergstrom, 1717 South 29th St., Omaha 5, Neb.

FOR SALE — Dynamotor 6 v. input 500 v. at .375 amp. output good cond., \$10; Mallory vibrapack with new vibrator 250 v. at .060 amp., \$5; 6 v. solenoid type heavy duty mobile relays, \$2. G. W. Carter, 8015 Loyola Blvd., Los Angeles 45, Calif.

FOR SALE — Capacitance bridge for non-electrolytic condensers. Range 20 mmf to 10 mfd, 1000 cycle tone source included. Will ship prepaid for \$10. Gerard Baldauf, 3137 Philmont Ave., Hungington Valley, Pa.

FOR SALE — Hi-Fi V-M Triomatic record changer with GE variable reluctance cartridge. Blonde base included. Good cond., Popular Photography magazines 1952-1956. Ralph Landers, 4933 Elmwood Ave., Los Angeles 4, Calif.

FOR SALE — Gonset 6 meter communicator; SX28A; Sonar MR3 mobile rcvr; MB26 Sonar 2 meter xmtr; Gonset 2 meter converter; E400 sweep gen. A. Turturro, 146-26 No. Hempstead Tpke., Flushing 55, N. Y.

WANTED — Old type GE FM translator, type JFM-90 having 40-50 mc frequency range for original FM broadcast band. Should have unaltered circuit. Advise cond. and price. L. F. Carini, Box 153, Wethersfield, Conn.

FOR SALE — Stancil-Hoffman Corp. Mini-Tape and battery charger, any reasonable offer accepted. Local buyer preferred. Needs some maintenance. George Jowdy, WVDA, Boston, Mass.

SELL OR TRADE — 2" x 2" old-time movie slides, collector's item. Want RF oscillator tuner Type Appolo projector. C. R. Keller, 8100 Hillendale Rd., Baltimore 4, Md.

FOR SALE — Eico 325 sig. gen., \$35. Want good scope and sweep gen. for cash. Norman Inventasch, 320 E. 176 St., Bronx 57, N. Y.

WANTED — Used tape recorders: state make, model, age, serial and lowest price, for your city. Tape Recorder Sales Co., 433 S. Wabash Ave., Chicago 5, Ill.

SWAP OR SELL — Recognized import-export course for electronic parts or \$15. Other items to swap. R. W. Spinillo, c-o USS Importers, 565 N. Coles Ave., Maple Shade, N. J.

WANTED — Beam rotator and indicator for 20 meter 3 element beam, voltmeters and millammeters for KW final, KW plate xformer, chemical laboratory equip. George Brown, 7001 Bancroft St., Toledo, Ohio.

SELL OR TRADE — Admiral and Spartan 78 speed record changers in good cond. Plays 10 and 12" records. No bases. Make offer. Troy S. Starr, 29 Rosedale Dr. Binghamton, N. Y.

WANTED — Buy or rent Instruction book and Schematic for 581 Supreme sig. gen. T. A. Milam, Box 1033, Decatur, Ala.

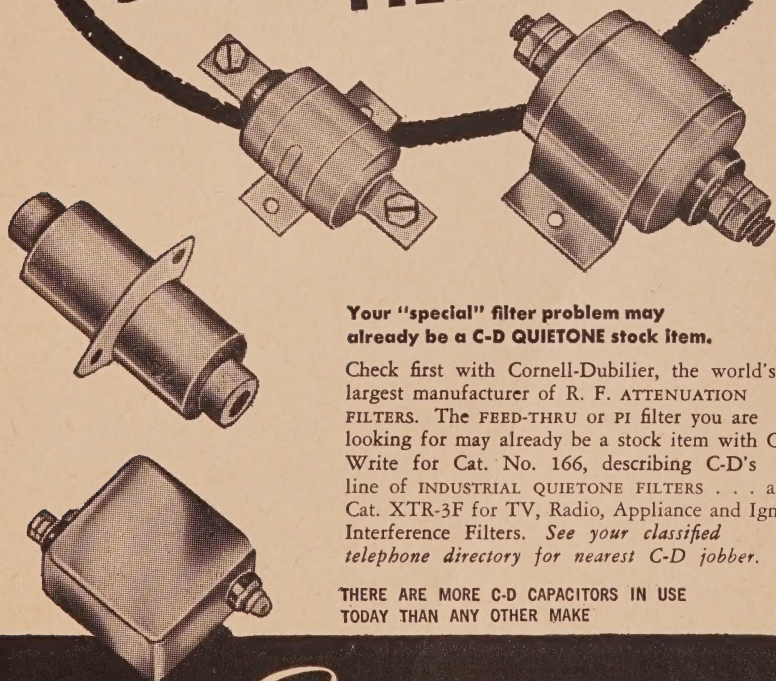
WANTED — Used FM xmtr rcvr units. Band range 152 to 162 Mc. Radio Dispatch Service, Box 595, Fairfield, Ala.

FOR SALE — Combination of 1947, 48, 49 NRI courses, 77 study books, also included are 33 NRI books on How to Make Extra Money Fixing Radios. Price: \$10. Donald Hoffman, 30 Babcock St., Brookline 46, Mass.

WANTED — Instruction manual for Supreme tube tester model I-177-B. Will pay reasonable price and postage. W. A. Smith, 135th and Archer, Lemont, Ill.

FOR SALE — National NC-46 rcvr, speaker, clean, good cond., \$35. P. Winter, 24 Jane St., New York 14, N. Y.

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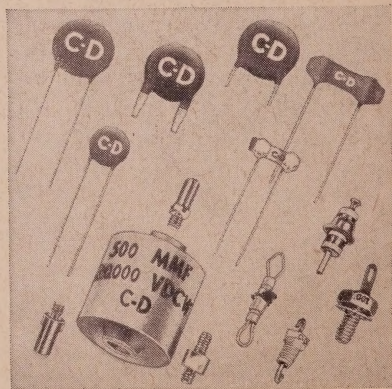
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